An Analysis of Collaborative Research Opportunities for the Army

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The research described in this report was sponsored by the United States Army under Contract No. DASW01-96-C-0004.

Library of Congress Cataloging-in-Publication Data

Wong, Carolyn [DATE].
An analysis of collaborative research opportunities for the Army / Carolyn Wong.
p. cm.
"Prepared for the United States Army by RAND's Arroyo Center."
"MR-675-A."
Includes bibliographical references.
ISBN 0-8330-2506-6
1. Military research—United States. 2. Research and development partnership—United States. 3. United States. Army. I. Arroyo Center. II. United States. Army. III. Title.
U393.W66 1998
355'.07'0973—dc21 97-20770
CIP

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Published 1998 by RAND
1700 Main Street, P.O. Box 2138, Santa Monica, CA 90407-2138
1333 H St., N.W., Washington, D.C. 20005-4707
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Carolyn Wong

Prepared for the
United States Army

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PREFACE

This report demonstrates that the Army has significant opportunities to more effectively achieve its research and development (R&D) goals through collaboration with industry. The report is one of two documents that address the issue of collaboration with industry. The second report focuses on how the Army can effectively implement a collaboration policy (see Kenneth P. Horn et al., *Performing Collaborative Research with Nontraditional Military Suppliers,* Santa Monica, CA: RAND, MR-830-A, 1997).

This research was sponsored by Mr. Michael Fisette, Principal Deputy for Technology, AMC Headquarters, and is being conducted within the Arroyo Center's Force Development and Technology Program. The Arroyo Center is a federally funded research and development center sponsored by the United States Army.

The findings should be of interest to those concerned with strategies for managing advanced technology development.

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SUMMARY

INTRODUCTION

The Army is encountering trends that may impede its ability to maintain its technological edge. Its science and technology (S&T) budget is decreasing, and commercial firms now hold the technological lead in many areas important to the Army. Furthermore, growth in international technological capabilities, increased competition from European and Japanese firms, and an emerging U.S. ideological shift away from government involvement in research and development (R&D) all point to a need for the Army to investigate new methods to accomplish its R&D goals.

Collaboration with industry to achieve Army R&D goals is one promising new approach that offers a number of benefits, and the Army can use recently introduced instruments to execute such agreements. Army collaboration, for the purposes of this study, means that the Army forms a partnership with a commercial entity to jointly conduct research and development.[1] This study uses a unique approach to evaluate Army technologies with respect to their potential as collaboration candidates; it also determines whether there are sufficient opportunities available to justify pursuing a collaboration policy.

[1]A commercial entity can be a traditional military supplier, a commercial firm that does not usually do business with the Army, or a consortium of companies. We will use the term "industry" to refer to a commercial entity that is controlled by the laws of the United States. That is, firms controlled by foreign entities are not included because their participation in joint efforts may be constrained by U.S. law.

BENEFITS OF COLLABORATION

Collaboration offers a number of benefits to the Army. For example, there are many firms that do not perform R&D with or for the Army but are doing leading-edge R&D in technologies of Army interest. By collaborating with such firms, the Army can exploit their technological leads and achieve technological advances both faster and cheaper. Partnering with industry can also introduce new sources of R&D money to the Army through cost sharing. The Army can also pool resources with industry to accomplish objectives that are too expensive to accommodate in its own R&D budget. In addition, collaboration can reduce the chance of duplicating work that has already been done by industry. The Army may also be able to recoup some of its R&D costs through recovery of funds, which is allowed under recently introduced instruments.

INSTRUMENTS TO EXECUTE COLLABORATIONS

In the past, the Army may have been deterred from using collaboration as a principal R&D management strategy because few instruments were available for conducting collaborative R&D. Cooperative Research and Development Agreements (CRADAs), which were created as mechanisms to transfer technology from the government to industry (spin-offs), are not efficient or effective as mechanisms to transfer technology from industry to the military (spin-on). Conventional contracts and grants require adherence to many government regulations. In many instances, these instruments have proved too restrictive to attract industrial firms that are recognized technological leaders. With the introduction of newer, more flexible instruments, such as Other Transactions (OTs) and Cooperative Agreements (CAs), the Army will now find it easier to conduct collaborative R&D with industry.

THE COLLABORATION ASSESSMENT FRAMEWORK

To determine whether there are Army technologies suitable for collaboration with industry, we developed a two-dimensional framework partitioned into four management domains. The two dimensions are market breadth, designed to indicate industry's interest in a technology, and Army utility, designed to reflect the technology's

potential contribution to helping the Army accomplish its mission. The market-breadth dimension ranges from Army unique (the technology has potential use to the Army alone) to generic (the technology has potential government and commercial uses); the Army-utility dimension ranges from low (the technology does not contribute to the Army's future combat capability) to high (the technology is critical to that capability).

The four management domains—which partition the above framework—are lead, initiate, participate, and monitor. Technologies falling into the lead domain tend to be those that are Army unique and, thus, not suitable for collaboration with industry; technologies in the monitor domain have relatively low Army utility, which argues against their suitability for collaboration with industry. Technologies that fall into the initiate and participate domains have high Army utility/high industry interest or moderate Army utility/moderate industry interest, respectively, and are thus good candidates for collaboration.

ASSESSMENT OF THE ARMY'S COLLABORATION OPPORTUNITIES

Using the above framework, we assessed the technologies found in the Army's fiscal year 1995 Research, Development, Test, and Evaluation (RDT&E) Program under the basic research, applied research, and advanced development headings. The analysis showed that a considerable number of technologies fall into the initiate and participate domains and are, thus, good collaboration candidates. Specifically, 17 out of 28 basic research technologies, 14 out of 28 applied research technologies, and 7 out of 32 advanced development technologies fell within the two domains.

While the above analysis determined that many technologies are good collaboration candidates, it did not tell us how much money is spent on the suitable technologies. If, for example, the Army spends only a small amount on the suitable technologies, then a collaboration policy may be inappropriate. To determine the amount of R&D funds that fall into the two domains, we used budgetary figures for fiscal years 1993, 1994, and 1995 (proposed) for the RDT&E program technologies. We found that a substantial amount of R&D funds are

spent on potentially collaborative technologies in the two domains—47, 50, and 51 percent of the total R&D funds spent in fiscal years 1993, 1994, and 1995, respectively. In addition, when we examined an illustrative subset, within the two domains, of eight technology areas in fiscal year 1995 that are of particular interest to the Army and have a recognizable industry leader that has not historically done business with the Army, we find that those areas amount to a substantial amount of fiscal year expenditures—approximately $514 million of the Army's $1.49 billion fiscal year 1995 budget request.

CONCLUDING REMARKS

Hence, the Army stands to benefit from collaboration with industry. It has a wide spectrum of instruments to execute collaborative efforts; there are a large number of technologies that are good collaboration candidates; and the Army spends a significant amount of R&D funds on technologies that are good collaboration candidates. Collectively, these facts indicate that the Army should adopt a policy that considers collaboration as a primary R&D approach.

ACKNOWLEDGMENTS

The author wishes to thank Ken Horn for his steadfast encouragement and enthusiastic support of this work; Elliot Axelband for his thoughtful review; Frank Camm for his detailed comments and insightful review; John Birkler and Dave Kassing for their constructive comments; Judy Larson for helping structure the document; Paul Steinberg for his many excellent suggestions for the final version of the report; Nikki Shacklett for her editing help; and the other team members, Ike Chang, Lucille Horgan, and Howell Yee, for sharing their perspectives throughout the task.

ABBREVIATIONS

AIDS	Acquired Immune Deficiency Syndrome
AMC	Army Materiel Command
ARL	Army Research Laboratory
ARPA	Advanced Research Projects Agency
BAA	Broad Agency Announcement
ASAT	Anti-Satellite Weapon
ATAS	Advanced Tank Armament System
C2	Command and Control
C3	Command, Control, and Communications
CAs	Cooperative Agreements
CFR	Code of Federal Regulation
CIE	Clothing and Individual Equipment
CRADAs	Cooperative Research and Development Agreements
CSS	Combat Service Support
DFARS	Defense Federal Acquisition Regulation Supplement
DIS	Distributed Interactive Simulation
DoD	Department of Defense

DoDGARs	Department of Defense Grants and Agreements Regulations
FAR	Federal Acquisition Regulation
FY	Fiscal Year
FY95	Fiscal Year 1995
FY95$	Fiscal Year 1995 dollars
GAAP	Generally Accepted Accounting Practices
HBCU/MI	Historically Black Colleges and Universities/ Minority Institutions
LOSAT	Line-of-Sight, Anti Tank
NBC	Nuclear, Biological, and Chemical
N-LOS	Non-Line of Sight
OMB	Office of Management and Budget
OSD	Office of the Secretary of Defense
OTs	Other Transactions
R&D	Research and Development
RDT&E	Research, Development, Test and Evaluation
SINCGARS	Single Channel Ground and Airborne Radio System
S&T	Science and Technology
SSM	Surface-to-Surface Missile
TACOM	Tank-automotive and Armaments Command
U.S.C.	United States Code

Chapter One

INTRODUCTION

BACKGROUND

The Army is encountering trends that may impede its ability to maintain its technological edge. First, as its science and technology (S&T) budget continues to shrink, the Army may not have enough money to adequately fund the efforts required to achieve its research and development (R&D) goals in all technologies. Second, commercial firms now hold the technological lead in many areas important to the Army. Finally, growth in international technological capabilities, increased competition from European and Japanese firms, and an emerging U.S. ideological shift away from federal government involvement in R&D all point to a need for the Army to investigate new methods to accomplish its R&D goals.

Collaboration with industry is one promising new approach. In the context of this study, Army collaboration means the Army forming a partnership with a commercial entity to jointly conduct R&D.[1]

OBJECTIVE

This study's objective is to assess the Army's R&D collaboration opportunities. We chose to focus on collaboration opportunities with

[1]A commercial entity can be a traditional military supplier, a commercial firm that does not usually do business with the Army, or a consortium of companies. We will use the term "industry" to refer to a commercial entity that is controlled by the laws of the United States. That is, firms controlled by foreign entities are not included because their participation in joint efforts may be constrained by U.S. law.

industry because there are many firms doing leading-edge R&D in technologies of Army interest—for example, textiles and information technologies such as telecommunication systems—that are not now engaged in collaborative efforts with the Army. By collaborating with such firms, the Army can exploit their technological leads and achieve technological advances for itself both faster and cheaper.[2]

Collaboration can bring other benefits to the Army as well. Partnering with industry can introduce new sources of R&D money to the Army through cost sharing. For example, collaboration can allow the Army to leverage its scarce and decreasing R&D resources to more effectively and efficiently accomplish its R&D objectives. The Army can pool resources with industry to accomplish objectives that are too expensive to accommodate in the Army R&D budget. Collaboration can also reduce the chance of the Army's duplicating work already done by industry. The Army may also be able to recoup some of its R&D costs through a recovery of funds that is allowed under recently introduced instruments. Collaboration may result in some auxiliary benefits. For example, the Army could be exposed to ideas and approaches that could have a positive effect on the way it thinks about requirements. Collaboration might also result in new sources of supply for needed products and services.[3]

INSTRUMENTS FOR EXECUTING COLLABORATION

Here we discuss the spectrum of instruments the Army can use to execute collaborative R&D—a spectrum that is summarized in Table 1.1.[4]

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[2]Partnering with foreign entities might offer high potential for the Army to exploit a technological lead. For example, Japan currently has the technological lead in flat-panel displays. But such ventures would require the Army to contend with an additional set of regulations and policies about national security and national economic vitality.

[3]Partnering with other services, other parts of the Department of Defense (DoD), federal agencies, state governments, and local governments can bring the Army some of the same benefits. In these cases, however, the Army would usually not have an opportunity to benefit by exploiting a technological lead from its government partner.

[4]An extensive discussion of instruments appropriate for collaboration can be found in the companion volume to this report: Kenneth P. Horn et al., *Performing Collaborative Research with Nontraditional Military Suppliers*, Santa Monica, CA: RAND, MR-830-A, 1997.

Table 1.1

Characteristics of Instruments for Collaboration

Feature	Contract	Cooperative Research and Development Agreement	Cooperative Agreement	Other Transaction
Administrative regulations	Rigid, cumbersome (FAR/DFARS)	Minimal	Waived guidelines (DoDGARs)	Commercial practice (GAAP)
Cost to bid	Lengthy proposals	Short proposals	Short proposals	Short proposals, white papers
Management oversight	Frequent meetings, extensive reporting	Minimal	Reduced	Reduced
Intellectual property rights	Government owns	Specified, but may be negotiable	Inventor owns and government has fully paid, nonexclusive license (Bayh-Dole Act)	Negotiable
Subcontractor relationship	Rigid, complex	Usually not applicable	OMB Circular A-110, Attachment O	Commercial practice
Socioeconomic requirements	Numerous	Minimal	Participation of HBCU/MI by policy	Minimal (Civil Rights Act of 1964)
Fee	Allowed	Not permitted	Not permitted	Not permitted
Cost sharing	No	No government funds can be spent on a CRADA	Optional (10 U.S.C. §2358) Extent practicable (10 U.S.C. §2371)	Extent practicable
Recoupment, augmentation	No	Royalties OK	No (10 U.S.C. §2358) Optional (10 U.S.C. §2371)	Optional
Oversight	Contracts officer, program office	Minimal	Grants officer	Negotiable (board of directors concept)

Cooperative Research and Development Agreements

Until recently, the Army may have been deterred from using collaboration as a principal R&D management strategy because few instruments were available for it to conduct collaborative R&D. In the past, Cooperative Research and Development Agreements (CRADAs) were the principal instruments for collaborative efforts. CRADAs are business, not procurement, contracts that allow the government and industry to cooperate and share intellectual property resulting from joint efforts.

Under a CRADA, the industry partner is allowed to contribute resources such as personnel, services, property, and funding to the effort. The government can contribute all the above except funding. For example, under a CRADA, the Army can enter into joint R&D efforts in which it provides all or some of the required facilities, equipment, and materials as well as some personnel.

CRADAs were created as mechanisms to conduct joint R&D for mutual benefit or to transfer technology from the government to industry (spin-offs) and thereby help improve U.S. competitiveness. They were not designed as mechanisms to efficiently transfer technology from industry to the military (spin-ons). CRADAs are not effective instruments to allow the Army to take advantage of technological leads held by industry.

Conventional Contracts

Conventional contracts, although not specifically designed to be instruments to conduct collaborative research, can be used to execute joint efforts. However, conventional contracts require adherence to burdensome regulations such as the Federal Acquisition Regulation (FAR), Defense Acquisition Regulation Supplement (DFARS), or Department of Defense Grant and Agreement Regulations (DoDGARs). In many instances, this sort of instrument has proved too restrictive to attract many industrial firms that are recognized technological leaders in their fields, either because of the management, accounting, or other regulations that apply or to the high cost to bid.

Cooperative Agreements

Substantial government participation in the research characterizes Cooperative Agreements (CAs). There are several variations of CAs. The primary difference among them is a recovery-of-funds feature. All CAs are authorized by Title 10 U.S. Code Section 2358 (10 U.S.C. §2358). However, the recovery-of-funds clause in 10 U.S.C. §2371 can be invoked to include a recovery provision in a CA. We will call CAs without recovery-of-funds clauses "10 U.S.C. §2358 CAs," and those with such a clause "10 U.S.C. §2371 CAs." A recovery-of-funds clause can be attractive to the Army because it allows for account augmentation that has not been possible under conventional contracts. If a CA is desired, the government and its partner can usually select the variation that is most appropriate for the joint effort.

CAs are designed to allow the government to more easily conduct collaborative R&D with industry. 10 U.S.C. §2371 CAs allow the Army to cost share by contributing money to the collaborative effort.[5] For example, 10 U.S.C. §2371 CAs allow for joint ventures on specific research, with the Army bearing part of the cost and its industry partner(s) bearing the remaining costs. Other examples of collaborative efforts that are allowed under a 10 U.S.C. §2371 CA include joint funding of broader agendas of research conducted at multiple sites, and jointly funded and managed research at a single industrial or Army site.

Other Transactions

Other Transactions (OTs) are authorized by 10 U.S.C §2371. OTs are the most flexible instrument, in that fewer regulations apply to them than to other instruments. OTs also allow return on investment for the Army. Hence, the Army can, for example, enter into an OT that invests in a startup company doing innovative research in a technol-

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[5]Recall that CRADAs prohibit the government from contributing funds to the joint effort. Cost sharing is to be exercised to the maximum extent practicable for 10 U.S.C. §2371 CAs and OTs.

ogy of interest to the Army. Such an OT arrangement can be designed to yield equity interest to the Army.[6]

OTs can also facilitate the Army's ability to take advantage of technological leads held by industry. When industry holds the technological lead, it may not be particularly eager to enter into a collaborative agreement that would let the Army exploit that lead. OTs are flexible enough to allow the Army to design an agreement in which its industry partner sees some financial advantages to entering into a collaboration. For example, the industry might be very interested in cost sharing. The Army can also negotiate other terms that might "compensate" industry for Army exploitation of a technological lead. For example, industry might be persuaded by the Army's ability and willingness to negotiate particularly favorable joint-effort intellectual property rights.

The flexibility of OTs includes the waiver of almost all regulations that would force a prospective industrial partner to change its way of doing business. Exercising this feature can make the OT a powerful instrument for the Army to use to attract industry into R&D partnership.

RESEARCH APPROACH

The study team developed a two-dimensional framework, partitioned into management domains, that was appropriate for evaluating Army technologies with respect to their potential as collaboration candidates. We applied the framework to Army R&D technologies to identify which of them might be the most suitable candidates for each of the management approaches. In particular, we showed where collaboration may present opportunities for the Army to realize such benefits as exploiting technological leads to achieve R&D goals faster and cheaper. We also performed a budgetary analysis of recent and proposed Army research and development resource allocations, showing that a substantial amount of Army R&D money is being spent on technologies that are good collaboration candidates.

[6]For such innovative uses of OTs, it is still unclear which part of the Army would receive the return on the investment—e.g., the Army laboratory that performed the joint research, the command, or the Department of the Army.

By integrating the budgetary analysis with the application, we determined that more Army collaboration with industry in selected technologies can enhance the effective use of Army research and development funds.

ORGANIZATION OF THIS REPORT

Chapter Two contains a discussion of the collaboration assessment framework. Chapter Three contains an analysis of Army technologies using the framework. In addition, Chapter Three includes a budget analysis and our integration of that analysis with the application of the framework. Chapter Four contains concluding remarks.

Chapter Two

THE COLLABORATION ASSESSMENT FRAMEWORK

To determine whether there are Army technologies suitable for collaboration with industry, we developed an approach that involves a two-dimensional framework partitioned into four management domains.[1] Below we discuss the two dimensions and the four management domains in more detail.

FRAMEWORK DIMENSIONS

Figure 2.1 shows the framework developed for identifying the most promising collaboration technologies. It has two dimensions: market breadth and Army utility.

Market Breadth

The market breadth dimension is designed to indicate industry's interest in a technology. Without this information, it would be difficult for the Army to ascertain whether it could find potential partners to perform R&D in the technology area. If a technology has many potential government and commercial uses (everybody wants it), then industry's interest is likely to be higher than if the technology had potential use for the Army only (it is Army unique). Industry's interest in the former case is likely to be higher, since advances in the

[1]We examined a number of alternatives in our search for a tool. We adapted a concept developed to categorize Navy technologies. See Kenneth Saunders et al., *Priority-Setting and Strategic Sourcing in the Naval Research, Development, and Technology Industrial Base,* Santa Monica, CA: RAND, MR-588-NAVY/OSD, September 1995.

technology have potential uses in many products or services. Hence, industry is likely to perceive such a technology as more likely to result in higher profits. In our framework, market breadth is represented as a continuous scale that ranges from a technology having potential Army uses only (Army unique), to potential military uses only, to potential government uses only, to potential government and commercial uses (generic).

Army Utility

Army utility reflects a technology's potential contribution to helping the Army accomplish its mission. In our framework, Army utility is represented as a continuous scale that ranges from low to high. A technology with low Army utility is one that is not expected to contribute directly to the Army's future combat capability. On the other hand, a technology that is critical to maintaining future combat capabilities has high Army utility.

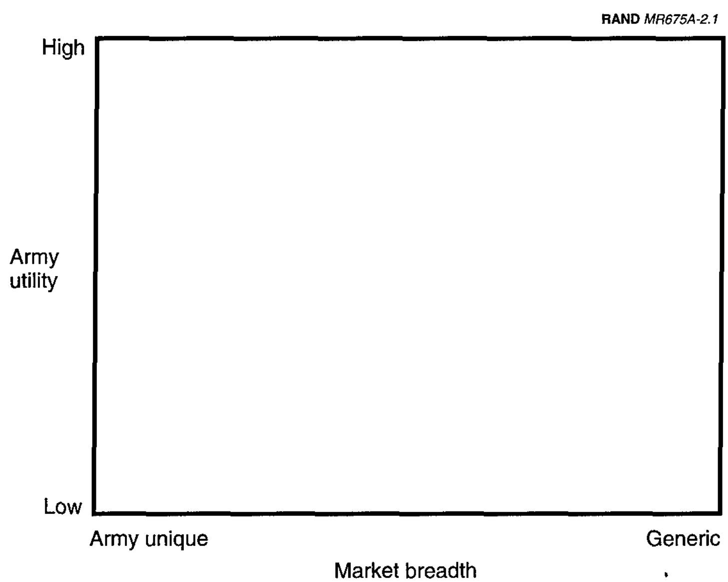

Figure 2.1—The Collaboration Assessment Framework

DEFINING MANAGEMENT DOMAINS

The Army and the Department of Defense (DoD) have traditionally judged the progress and success of R&D efforts in terms of three benchmarks—performance, schedule, and cost/budget[2] characteristics. As shown in Figure 2.2, our framework comprises four management domains, which reflect different approaches to managing the three benchmarks.[3] Our discussion below is presented from the Army's viewpoint.

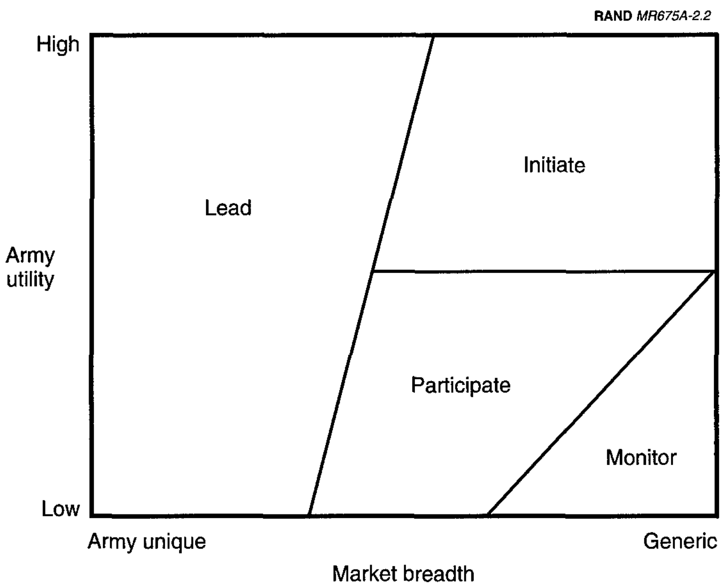

Figure 2.2—Management Domains Within the Collaboration Assessment Framework

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[2]We use the more general term "resources" to include cost/budget.

[3]The domains we show in Figure 2.2 have fuzzy borders. There is no line or curve on the framework above, below, left, or right of which a particular management approach can be judged most appropriate.

Lead

When the Army chooses to lead, it defines the performance goals, provides the vision, and specifies the potential products or capabilities. The Army also sets forth its schedule requirements and sets the resource (cost/budget) constraints. Under an Army-lead management approach, the Army uses contractual measures to control performance, schedule, and use of resources (budget).[4] The instrument the Army generally chooses to carry out its plan is a formal agreement with a contractor such as a conventional contract. In the lead role, the Army is conducting "business as usual," and the contracted activities are usually not collaborative.

Initiate

When the Army chooses to initiate, it defines its performance goals, provides its vision, and specifies products and capabilities of Army interest. The Army may also set forth its schedule requirements and set its resource (cost/budget) constraints. In its proactive search for a collaborating partner in industry, the Army may look for areas of intersection among its performance goals and those of potential industrial partners. Since these technologies are primarily of high Army utility, the Army may place heavy emphasis on finding an intersection of performance goals, rather than negotiate a set of goals. The Army may also look for compatible schedules or negotiate an acceptable schedule. The Army may also negotiate a set of resource constraints. Under an Army-initiate management approach, the Army tries to control performance but may share control of schedule and use of resources. Approaches likely to be appropriate are formal agreements with industrial partners using instruments that lend themselves to collaborative efforts. These instruments include Cooperative Research and Development Agreements (CRADAs), Cooperative Agreements (CAs), and Other Transactions (OTs). In the initiate role, the Army is collaborating with industry. In such an effort, the Army should achieve the same or nearly all the same goals it would achieve if it conducted the activity without collaboration.

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[4]A prime contractor generally executes the Army's plan.

Participate

When the Army chooses to participate, it may negotiate acceptable performance goals if it cannot find an appropriate intersection with industrial performance goals. The Army may also negotiate an acceptable schedule as well as a set of resource constraints. Under an Army-participate management approach, the Army has shared control of performance, schedule, and use of resources. Approaches that are likely to be appropriate are formal agreements with industrial partners using instruments that lend themselves to collaborative efforts. These instruments include CRADAs, CAs, and OTs. In the participate role, the Army is collaborating with industry. In such an effort, the Army should achieve at least some of the same goals it would achieve if it conducted the activity without collaboration.

Monitor

A primary characteristic of the this type of approach is two-way communication between the Army and industry through informal means. When the Army chooses to monitor, it relies on vigilant communication of Army performance and schedule goals to industry, but it makes only very limited or no resource commitments to accomplish its performance goals. In the monitor role, the Army does not have a formal role and has no control over performance, schedule, or use of resources committed to research and development activities. The instrument is informal; for example, communication occurs through established working relationships, workshops, conferences, and seminars.

THE COLLABORATIVE DOMAINS

Since industry interest is required for collaboration to be successful, the right-hand region of the framework, where industry interest is moderate to high, is the general area where collaboration is likely to work. In particular, the initiate, participate, and monitor domains lend themselves to collaborative management approaches. Under tight fiscal constraints, however, the Army may find that it must dramatically lower or eliminate its R&D funding in some technologies. We argue that the candidates for reduced funding are those with low Army utility—that is, those in the lower half of the frame-

work. Among those with low Army utility, those with high industry interest (i.e., technologies in the monitor domain) may be better candidates for lowered Army funding because R&D is more likely to be continued in those technologies through industry funding. R&D activities are unlikely to continue in Army-unique technologies without Army funding. Hence, for this study we will consider the initiate and participate domains to be the collaborative domains.[5]

Table 2.1 summarizes typical performance, schedule, and cost benchmark characteristics of the four management approaches in the framework. Once again, the demarcations between the management approaches are fuzzy.

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[5]We recognize that these statements are generalities and that whether the Army should make an expenditure to exploit a technological lead held by industry for a technology in the monitor domain should be decided on a case-by-case basis. Many factors will figure into such a decision, including the amount of expenditure required, what the Army will gain, and how tight the Army's fiscal constraints are.

Table 2.1

Benchmark Characteristics of Management Domains

Management Domain	Characteristics • Performance • Schedule • Resources	Effects • Control • Instrument • Collaboration
Lead	• Define performance goals, vision, products/capabilities • Set schedule • Set resource constraints (e.g., budget)	• Army has full control and responsibility for performance, schedule, and use of resources (e.g., budget) • Instrument is usually a formal agreement (e.g., Request for Proposal followed by a conventional contract) • Usually not collaborative
Initiate	• Define performance goals, vision, products/capabilities • Set or negotiate acceptable schedule • Set or negotiate resource constraints (e.g., budget)	• Army controls performance, but might share control of schedule and resources (e.g., budget) • Instrument is usually a formal agreement (e.g., CRADA, CA, OT) • Can be collaborative
Participate	• Define key performance requirements and negotiate performance goals • Negotiate acceptable schedule • Negotiate resource constraints (e.g., Army's share of budget)	• Army shares control of performance, schedule, and resources • Instrument is usually a formal agreement (e.g., CRADA, CA, OT) • Should be collaborative
Monitor	• Vigilant communication of performance requirements • Communication of schedule requirements • Little or no resource commitments	• Army has no control of performance, schedule, or resources • Instrument is informal (e.g., communication through established working relationships) • Army does not have a formal role

Chapter Three

ASSESSMENT OF THE ARMY'S COLLABORATION OPPORTUNITIES

THE ARMY TECHNOLOGIES

For our application of Army technologies to the framework, we used the list of technologies found in the Army's fiscal year 1995 Research, Development, Test, and Evaluation (RDT&E) Program under the basic research, applied research, and advanced development headings.[1] We limited our considerations to technologies that showed a positive funding level for fiscal years 1993, 1994, or 1995 (proposed). This list of technologies is shown in Table 3.1.

APPLICATION OF ARMY TECHNOLOGIES TO THE FRAMEWORK

The project team placed the list of technologies shown in Table 3.1 on the framework. Each team member first independently determined each technology's placement on the framework. The team then convened for a series of discussion sessions to come to a consensus to place the technologies on which team members initially disagreed.[2] For computational convenience, we assumed a scale of zero to three for the market-breadth axis and for the Army-utility axis. A market-breadth value of zero indicated potential Army uses

[1]Our source is *RDT&E Programs (R-1)*, Department of Defense Budget for Fiscal Year 1995, Office of the Comptroller of the Department of Defense, February 1994. This document is also known as the R-1. In budgetary terms, basic research is known as 6.1 activities, applied research (also known as exploratory development) is known as 6.2 activities, and advanced development is known as 6.3 activities.

[2]See the appendix for a detailed description of the technology placement process.

Table 3.1

Army Technologies in the R-1

Basic Research	Applied Research	Advanced Development
Materials Technology	Logistics Advanced Technology	Advanced Command and Control Vehicle
Electronic Survivability and Fusing Technology	Medical Advanced Technology	Surface-to-Surface Missile Rocket System
Aviation Technology	Aviation Advanced Technology	Anti-Satellite Weapon
Electronic Warfare Technology	Weapons and Munitions Advanced Technology	Nuclear Munitions—Adv Dev
Missile Technology	Combat Vehicle and Automotive Advanced Technology	Non-Line of Sight (N-LOS)
Laser Weapons Technology	Command, Control, Communications Advanced Technology	Landmine Warfare and Barrier—Adv Dev
Modeling and Simulation	Manpower, Personnel and Training Advanced Technology	Smoke, Obscurant and Target Defeating System—Adv Dev
Combat Vehicle and Automotive Technology	Materials and Structures Advanced Technology	Armament Enhancement Initiative
Ballistics Technology	Acquired Immune Deficiency Syndrome (AIDS) Research	Artillery Propellant Development
Chemical, Smoke and Equipment Defeating Technology	Global Surveillance/Air Defense/Precision Strike Technology Demonstration	Armored Systems Modernization—Adv Dev
Joint Service Small Arms Program	Electronic Warfare Technology	Engineer Mobility Equipment—Adv Dev
Weapons and Munitions Technology		Adv Tank Armament System (ATAS)
Electronics and Electronic Devices		Army Data Distribution System
Night Vision Technology		Tactical Surveillance System—Adv Dev
		Tactical Electronic Support System—Adv Dev

Table 3.1 (continued)

Basic Research	Applied Research	Advanced Development
Human Factors Engineering Technology	Missile and Rocket Advanced Technology	Single Channel Ground and Airborne Radio System (SINCGARS)—Adv Dev
Environmental Quality Technology	Landmine Warfare and Barrier Advanced Technology	Soldier Support and Survivability
Non-System Training Device Technology	Joint Service Small Arms Program	Distributive Interactive Simulation—Adv Dev
Command, Control, Communications Technology	Line-of-Sight, Antitank (LOSAT)	Tactical Electronic Surveillance System—Adv Dev
Computer and Software Technology	Night Vision Advanced Technology	Night Vision Systems—Adv Dev
Military Engineering Technology	Military Engineering Advanced Technology	Aviation—Adv Dev
Manpower/Personnel/ Training Technology	Advanced Electronic Devices Development	Weapons and Munitions—Adv Dev
Logistics Technology	Chemical Biological Defense and Smoke Advanced Technology	Logistics and Engineering Equipment—Adv Dev
Medical Technology	Advanced Tactical Computer Science and Technology	Combat Service Support Computer System Evaluation and Analysis
ARMY Artificial Intelligence Technology	Eight classified programs	Nuclear Biological Chemical (NBC) Defense System—Adv Dev
Four classified programs		Medical Systems—Adv Dev
		Meteorological Data Systems
		Five classified programs

only (Army unique), and a market-breadth value of three represented potential government and commercial uses (everybody wants it). Similarly, an Army-utility value of zero indicated low Army utility, and a value of three indicated high Army utility.

Each team member received descriptive material on the technologies. To minimize the influence of current budget allocations on the placement of technologies on the framework, no budget information was included in the descriptive material, nor was it discussed or analyzed until after we finished our iterative discussions to resolve differences in opinion on where some technologies should be placed.

Figures 3.1, 3.2, and 3.3 show the respective placement of technologies in the basic research, applied research, and advanced development categories. Figure 3.1 shows that 17 out of 28 basic research technologies fall into the initiate or participate domains. Figure 3.2

RAND *MR675A-3.1*

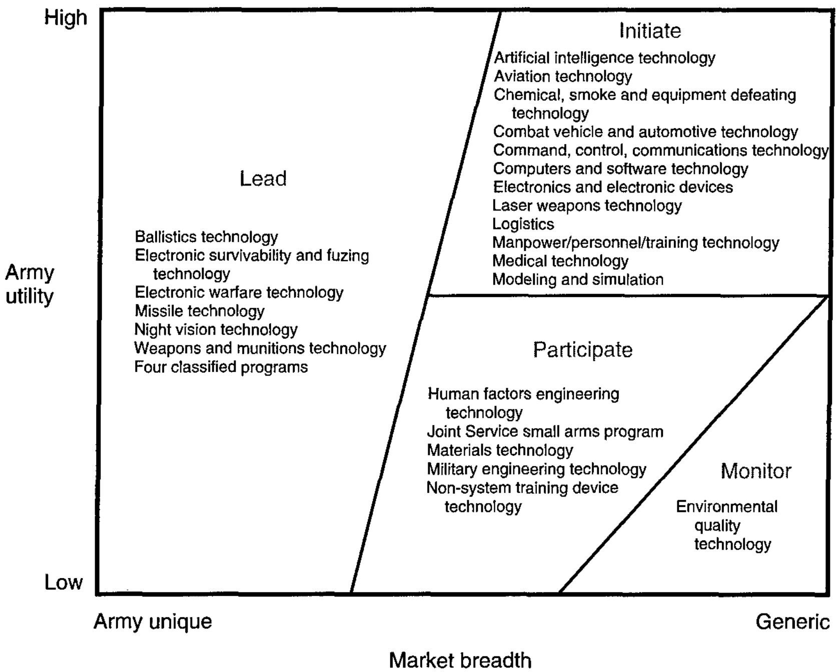

Figure 3.1—Placement of Basic Research Technologies

shows that 14 out of 28 applied research technologies fall into the initiate or participate domains. Figure 3.3 shows that 7 out of 32 advanced development technologies fall into the initiate or participate domains. Hence, in each category, there are many good candidates for Army and industry collaboration.

BUDGETARY ANALYSIS

In addition to knowing how many Army R&D technologies are good collaboration candidates, it is also important to know the magnitude of recent Army funding in these technologies. If the Army spends only a relatively small amount of money on them, say less than ten million dollars a year, then an Army-wide policy of collaboration may not be appropriate, since such an approach would not bring substantial financial benefits. If, on the other hand, the Army spends

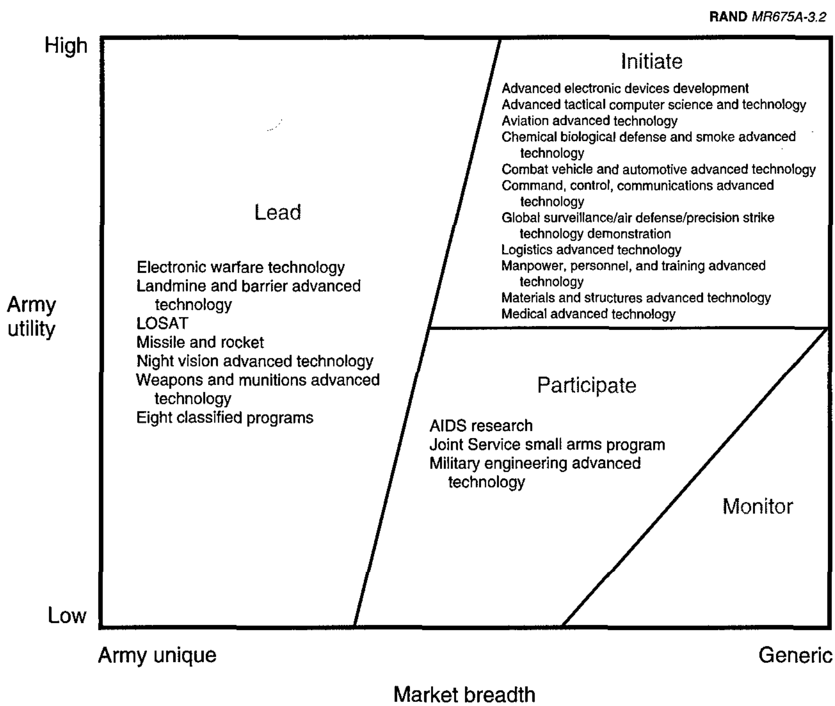

Figure 3.2—Placement of Applied Research Technologies

hundreds of millions of dollars annually in these areas, then collaboration can greatly enhance the effective use of its R&D funds.

In the context of our framework, we used the budgetary figures for fiscal year 1993, fiscal year 1994, and fiscal year 1995 (proposed) in the R-1 source, to calculate the recent and proposed funding for technologies in the lead, initiate, participate, and monitor management domains. Tables 3.2, 3.3, and 3.4 summarize the results, which are expressed in then-year dollars.

As shown in Tables 3.2 and 3.3, in fiscal year 1993 and fiscal year 1994 the Army spent more for research and development work in the lead domain than in the initiate, participate, or monitor domains. Table 3.4 shows that the Army proposed to spend $699,661K in fiscal year 1995 on basic research, applied research, and advanced development technologies that fall into the lead management domain.

RAND *MR675A-3.3*

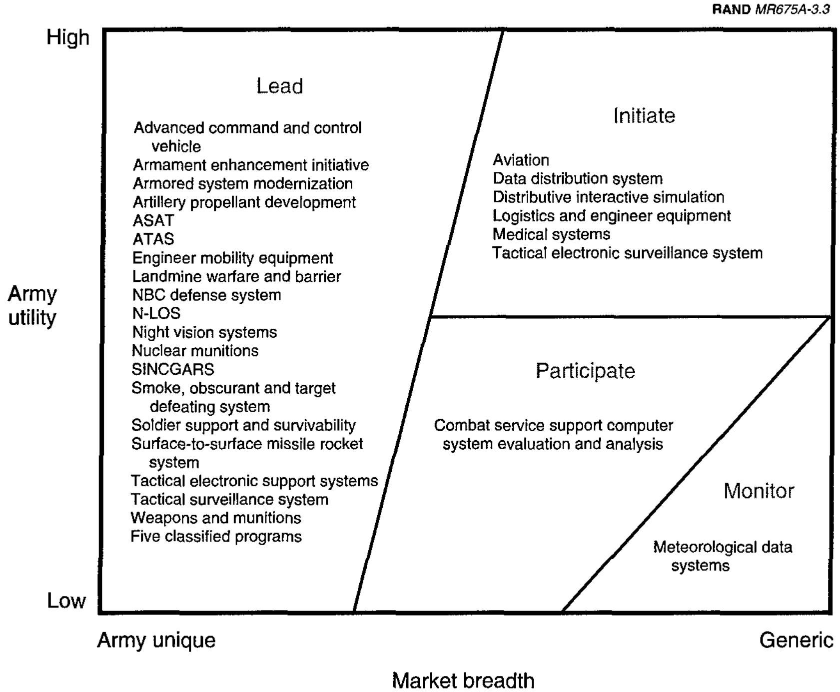

Figure 3.3—Placement of Advanced Development Technologies

Table 3.2

FY 1993 Funding Levels for Army Research Technologies in Thousands of Dollars

Research Category	Lead	Initiate	Participate	Monitor	Total
Basic research	247,415	298,230	81,312	62,731	689,688
Applied research	353,441	508,068	62,130	0	923,639
Advanced development	500,377	81,033	20,041	4,045	605,496
Total	1,101,233	887,331	163,483	66,776	2,218,823

Table 3.3

FY 1994 Funding Levels for Army Research Technologies in Thousands of Dollars

Research Category	Lead	Initiate	Participate	Monitor	Total
Basic research	184,155	276,626	81,595	54,123	596,499
Applied research	206,523	301,652	43,842	0	552,017
Advanced development	375,543	88,212	24,118	0	487,873
Total	766,221	666,490	149,555	54,123	1,636,389

Table 3.4

Proposed FY 1995 Funding for Army Research Technologies in Thousands of Dollars

Research Category	Lead	Initiate	Participate	Monitor	Total
Basic research	160,365	284,487	70,003	25,887	540,742
Applied research	228,011	291,514	21,760	0	541,285
Advanced development	311,285	64,825	18,876	0	394,986
Total	699,661	640,826	110,639	25,887	1,477,013

This amount is also larger than the amount the Army proposed to spend in any of the other management domains in fiscal year 1995. This observation is consistent with our expectation that the Army spent and proposed to spend most of its basic research, applied research, and advanced development funds in technologies that have potential uses only to the Army, the military, or the government (e.g., technologies that are close to Army unique in market breadth). This suggests that the Army has recognized that it must fund R&D activities in the lead technologies because industry may view these technologies as having a limited customer base and therefore limited profit potential. Hence, industry may be less likely to fund R&D in these technologies. From this perspective, the Army appears to be "doing the right thing" with its budgetary allocations by investing R&D funds in technologies where industry might not be.

In our application of Army technologies to the framework, we found that there are a substantial number in all three research categories that fall into the collaborative domains: initiate and participate. In terms of funding levels, Table 3.5 summarizes the amount spent or proposed to be spent in fiscal years 1993 through 1995. The table shows that about half of Army R&D funds are being spent on research in technologies that are good collaboration candidates.

CURRENT ARMY COLLABORATIVE EFFORTS

In some of the technologies that fall in the initiate and participate management domains, the Army has already started collaborative efforts. For example, in Project Plowshares, the local government of

Table 3.5

Spending on Technologies in the Collaborative Domains in Thousands of Dollars

Fiscal Year	Then-year Dollars Spent	Percent of R&D Budget Spent
1993	1,050,814	47.36
1994	816,045	49.87
1995	751,865	50.88

Orange County, Florida is using Army-generated computer simulations to aid in disaster relief. The Army's Tank-automotive and Armaments Command (TACOM) has collaborated with the "Big Three" automobile manufacturers to form the National Automotive Center. Army and industry collaborative efforts are also ongoing in the information technology area. However, our analysis showed that there are many more technologies that are good candidates for Army and industry collaboration, and that the Army spends a significant amount of money for R&D in these technologies.

To illustrate this point, we randomly selected a set of eight areas that included one or more technologies in the initiate or participate domains. A technology area was included in our set if it contained at least one recognized industrial leader that has not historically done business with the Army. We limited the set to eight technology areas to keep our illustration manageable. They are shown in Table 3.6.

Table 3.6

Technology Areas Selected for Spending Illustration

Technology Area	Examples of Industrial Leaders That Historically Have Not Worked with the Army
Artificial intelligence	Expert Software; Network General Corp.
Automotive	Roush Industries
Electronics, C3, computers, and software	Apple Computer, Inc.; QUALCOMM Incorporated
Human factors	Cannondale Corp.; The Coleman Co., Inc.
Logistics	Federal Express Corp.; UAL Corporation
Materials	E.I. DuPont De Nemours & Co.; Minnesota Mining & Mfg. Co.
Medical	Genzyme Corp.; Biogen, Inc.
Models and simulation	The Walt Disney Company; Warner Bros., Inc.

We calculated the amount of fiscal year 1995 funding the Army proposed to spend in the eight selected areas. Figure 3.4 shows that the Army proposed to spend approximately $514 million (FY95$) of its $1.49 billion fiscal year 1995 6.1–6.3 budget request in these eight areas alone.

These facts indicate that there are many more potential opportunities for the Army to use its R&D funds more effectively through collaboration with industry; the Army has yet to exploit these opportunities.

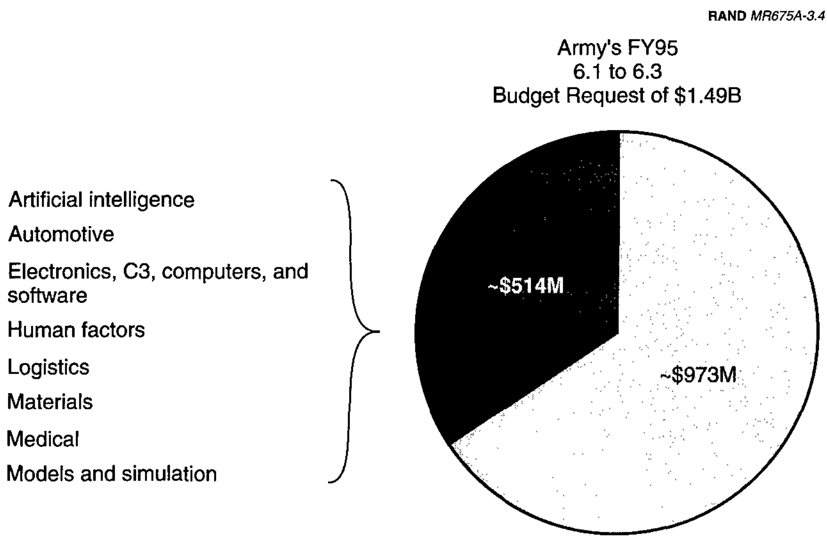

Figure 3.4—The Army's Proposed Budget for Eight Selected Technology Areas

Chapter Four

CONCLUDING REMARKS

In the previous chapter we illustrated how to use our framework to assess the Army's collaboration opportunities. The framework helped us categorize the technologies by management domain. We offer the following guidelines to help the Army interpret the results of the framework application.

For those technologies in the lead domain, the Army should expect to spend its own funds in order to realize the benefits of technological advances. In most of these cases and particularly for technologies that are Army unique, the Army should expect to use a conventional contract and might even have to offer a fee incentive to ensure that R&D moves toward Army goals.[1]

Technologies that fall in the initiate domain have high Army utility and high industry interest. Although industry might be funding R&D in these technologies, the Army might not wish to just stand by and rely totally on industry to meet Army goals. Instead, the Army may want to proactively initiate collaborative efforts to ensure that R&D in these areas addresses Army goals.

Technologies in the participate domain have moderate market breadth and moderate Army utility. Under tight fiscal constraints, neither the Army nor industry will have enough funds to invest much in these technologies. Collaboration may allow the Army and indus-

[1]Some of the technologies in the lead domain may be good candidates for the Army to explore teaming arrangements with other services, other parts of the DoD, and other federal agencies, state governments, or local governments.

try to pool resources to perform research and development in these areas. However, the Army may not want to spend more effort to proactively initiate research activities. For technologies in this domain, both the Army and industry can design and participate in activities for mutual benefit. Such efforts may require both the Army and industry to compromise on a set of R&D goals. Without a willingness to adjust goals, a joint investment may not be attractive enough to either the Army or potential industry partners.

Technologies in the monitor domain have low Army utility and high market breadth. Under tight fiscal constraints, the Army may have to let industry take the lead for technologies in the monitor domain and limit its own R&D investment there, restricting its role to one of proactive monitoring. Proactive monitoring could include low- or no-cost activities such as establishing working relationships with industry leaders and regularly (but informally) communicating Army needs in the technology, and attending workshops and conferences.

We have shown that the Army stands to benefit from collaboration with industry; it has a wide spectrum of instruments to execute collaborative efforts; there are a large number of technologies that are good collaboration candidates; and the Army spends a significant amount of R&D funds on technologies that are good collaboration candidates. Collectively, these facts indicate that the Army should adopt a policy that considers collaboration as a primary approach to achieve its R&D goals.

Appendix

PLACING TECHNOLOGIES ON THE FRAMEWORK

BACKGROUND OF PROJECT TEAM

The project team members who participated in the placement of technologies on the framework were RAND researchers with backgrounds in engineering, operations research, business management, and the physical sciences. Experience levels ranged from five years to decades of experience in research and development issues. Every team member had worked on Army research and development projects for at least several years, and all were familiar with the Army's current R&D program. Most team members had experience with commercial firms that did business with the Army.

MATERIALS AND GUIDANCE FURNISHED

Each team member was furnished with descriptive material on the technologies. To minimize the influence of current budget allocations on the placement of technologies on the framework, no budget information was included in the descriptive material, nor was it discussed or analyzed until after the iterative discussions to resolve differences in opinion on where some technologies should be placed.

Each team member also received guidance on how to interpret the endpoints of the market breadth and Army utility dimensions. For the market breadth axis, placement on the leftmost portion of the framework indicated "close to Army unique" and placement in the rightmost portion indicated "close to government and commercial uses (everyone wants it)." For Army utility, placement on the lower portion of the framework indicated that the technology's expected

contribution to helping the Army accomplish its mission is low or small. For example, technologies that did not directly contribute to maintaining future combat capabilities were to be placed near the bottom. A placement at the top of the framework indicated that the technology's expected contribution to the Army's mission is high or great. For example, technologies that are critical to maintaining future combat effectiveness should be placed near the top of the framework.

THE PLACEMENT PROCESS

For computational convenience, we assumed a scale of zero to three for the market-breadth axis and for the Army-utility axis. A market-breadth value of zero indicated potential Army uses only (it is Army unique), and a market-breadth value of three represented potential government and commercial uses (everybody wants it). Similarly, an Army utility value of zero indicated low Army utility, and a value of three indicated high Army utility.

For each technology in each of the three research categories, each member of the team specified a market breadth value and an Army utility value. Each team member worked independently to establish his initial values. One team member tabulated the results. The tabulated results showed consensus in most technology areas. For example, all team members specified values for environmental quality technology and meteorological data systems that placed these technologies in the monitor domain. Similarly, all team members specified values for medical technology and computers that placed these technologies in the initiate domain. In addition, all team members specified values for all classified programs, line-of-sight antitank, and landmine warfare technologies that placed these technologies in the lead domain. But there were also some technologies for which there was no initial consensus. For example, some team members viewed night vision as a lead domain technology, while others felt that it was an initiate technology.

We convened for a series of discussions to try to come to a consensus on technologies for which different team members specified widely different values for either market breadth or Army utility. For the purposes of this exercise, we considered "widely different values" to be values that differed by more than 0.5 and placed a technology into

different domains. Our discussions methodically moved from one technology to the next, but the placement for some technologies required multiple discussions. The discussions took place once a week for about a month. For the purposes of this exercise, we viewed values that would place the technology in the same management domain as a consensus. Hence, team members could adjust their specification of values to reach consensus but still have some leeway to express their opinion about where the technology should be placed on the framework.

The discussions resulted in modified values for some of the technologies by some team members. Any remaining discrepancies were adjudicated by the group leader. After the discussions, we averaged the market-breadth values and the Army-utility values for each technology in each category. The pair of average values for each technology in each category determined its placement on the framework.

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